DES
DEPARTMENT OF ENVIRONMENT AND SUSTAINABILITY
air quality · desert conservation PROGRAM · sustainability

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Marci Henson, Director

July 1, 2021

Elizabeth Adams, Director
Air and Radiation Division
U.S. Environmental Protection Agency, Region 9
75 Hawthorne Street
San Francisco, CA 94105

Re: Submittal of Clark County, Nevada, Exceptional Event Demonstrations for the 2015 Ozone NAAQS Las Vegas Valley Nonattainment Area

Dear Ms. Adams:

The Clark County Department of Environment and Sustainability (DES) is pleased to submit demonstrations for the following exceptional events. DES requests EPA initiate parallel processing of these demonstrations.

Event Date(s)	Event Type
June 19–20, 2018	Wildfire
May 6, 2020	Stratospheric Intrusion
May 9, 2020	Stratospheric Intrusion
May 28, 2020	Stratospheric Intrusion
June 22, 2020	Wildfire
June 26, 2020	Wildfire
September 2, 2020	Wildfire

Between 2018 and 2020, Clark County recorded several exceedances of the 2015 ozone National Ambient Air Quality Standard (NAAQS) that were caused by wildfire smoke or stratospheric intrusions. This submittal contains demonstrations for 8 of the 28 exceedance events in 2018 and 2020 that were identified in our November 30, 2020 Initial Notification of Intent summary and for which DES requests data exclusion. We will submit demonstrations for the remaining exceedance events by September 3, 2021, as agreed to in EPA's communication dated May 4, 2021. Responses to the detailed comments provided by EPA on April 16, 2021, concerning these events are also enclosed.

Under the Exceptional Events Rule (EER), codified at 40 CFR Parts 50.1, 50.14, and 51.930, air agencies may petition EPA to exclude air quality monitoring data influenced by exceptional events from applicable regulatory determinations. The attached demonstrations will show these exceedances would not have occurred without wildfire or stratospheric intrusion impacts.

Having fulfilled the requirements of the EER, DES requests EPA concur with the enclosed demonstrations and exclude the associated data from use in regulatory determinations for the 2015 ozone NAAQS in accordance with 40 CFR Part 50.14(b)(1). The Nevada Department of Environmental Protection will soon submit, under separate cover, a request for an EPA determination of attainment of the 2015 ozone NAAQS for the Las Vegas Valley nonattainment area based on exclusion of the 2018 and 2020 exceptional event data included in this and the subsequent September 3, 2021 submittal. That document will include a request for a one-year extension of the NAAQS attainment date if EPA does not concur with all proposed 2018 exceptional events and based on EPA's concurrence with all proposed 2020 exceptional events.

These demonstrations will be available for public comment for a 30-day period, beginning July 1, 2021, concurrent with EPA's review, in accordance with the requirements of 40 CFR Part 50.14(c)(3)(v). Documentation of the public comment process, along with all comments received and DES responses, will be submitted to EPA after conclusion of the comment period.

If you have any questions regarding this submittal, please contact Araceli Pruett at (702) 455-3206 or araceli.pruett@clarkcountynv.gov.

Sincerely,

Marci Henson

Marci Henson, Director

Attachment(s):
1. Demonstrations (7)
2. Statement Addressing EPA's Detailed Comments

cc:
Anna Mebust, EPA Region 9
Gwen Yoshimura, EPA Region 9
Randall Chang, EPA Region 9
Karina O'Connor, EPA Region 9
Sig Jaunarajs, NDEP
Daniel Dragoni, NDEP
Francisco Vega, Washoe County AQMD
Daniel Inouye, Washoe County AQMD
Araceli Pruett, Clark County DES

Response to EPA Region 9's WF Review

Our responses are in red beneath each comment. We greatly appreciate Region 9's willingness to review these demonstrations and the thoroughness of their review, which has helped to strengthen each demonstration.

Detailed, broadly applicable comments on 2020 demos (a subset of priority comments are in **bold**):

- HYSPLIT trajectory analysis:
    - Initiation times: it's unclear how these were selected. There are cases where they are selected based on "normal" peak ozone times, but in other cases different times were selected. **The timing is not chosen with consideration of the conceptual model.** The analysis becomes less cohesive that way because the trajectories are not timed to the observed data. Generally, the start times should be selected based on the data associated with the event, not on generalized data about peak ozone times. The timing should also be consistent with the timing of ozone concentration features of interest (peaks, increases, slope changes) and/or with the timing of claimed smoke impacts (e.g., if arguing smoke came in overnight and remained in the valley into the following morning, affecting O3 production, then trajectories should be timed from the suggested overnight smoke impacts).
        - For figures where the initiation times were selected based on a generalized "peak" ozone hour, HYSPLIT trajectories were rerun based on the characteristics of the event (e.g., peak ozone hour, rapid changes in ozone, overnight transport, etc.). Specifically, HYSPLIT trajectories were rerun to match the observed hourly peak ozone (e.g., September 2), match the beginning of a rapid increase (e.g., June 26), or match overnight transport (e.g., June 22 and September 2). For cases where the hourly peak ozone was chosen as the initiation time, if multiple sites exceeded the NAAQS standard at different hours, the median hour was chosen as the initiation time. New HYSPLIT trajectories were created for the June 22, June 26, and September 2 wildfire demonstrations, and are in Section 3.1.3 for each demonstration.
    - Starting heights: it was unclear why different starting heights were selected for the different versions of the trajectory analyses. It seems like this should be consistent or a justification of the different selected levels should be provided (or multiple vertical levels run for each analysis--this is more commonly what we've seen in Region 9 demos).
        - For new HYSPLIT trajectories (see Section 3.1.3) that were created, the starting heights were chosen on a case-by-case basis because the vertical profiles of the wildfires were often unknown. Therefore, the heights of the smoke plumes could not be defined. For example, the low starting height (250 m AGL) for the forward trajectories for the June 26 report was chosen because the wildfire in this instance was a fast-burning brush fire that was unlikely to inject smoke into the upper atmosphere. Low backward trajectory starting heights (e.g., 500 m AGL) for the June 22 report were chosen because starting heights lower in the atmosphere would show regional transport. Other forward trajectory heights were estimated based on their size, fuel type (biomass burned), and images of the fire. Backward trajectories were usually initiated at multiple heights to show transport throughout the lower boundary layer in the Las Vegas area.

    - There is not a lot of discussion on why the multiple HYSPLIT trajectory methods (single sites, matrix, etc.) were selected and how those different analyses provide different information to inform the demonstration. **In cases where the results are inconsistent, this should be explained within the context of the conceptual model.**
        - Text was included in Section 3.1.3 of the June 22, June 26, and September 2 documents to explain why different methods were used and why each method is useful. After re-working some of the HYSPLIT trajectories, none were inconsistent, but any inconclusive results were moved to the Appendix and an explanation on why they were inconclusive was added.
- Q/D analysis:
    - **Q/D should be calculated for ALL fires that the demonstration asserts contributed to the event (and ONLY fires that the demonstration claims impacted the monitors, i.e. only the fires that fit within the conceptual model).** It is unclear why in many cases this analysis only includes a subset of fires even when others are discussed in great detail elsewhere in the demo, particularly when trajectories are provided showing transport from those fires that weren't included in the table. It is also unclear why several fires sometimes appear in these tables that are not shown to be contributing via other CCR evidence in the demo. This may be due to a systematic application of STI's Q/D screening methodology, but it dilutes the conceptual model to include data from fires that are not part of the CCR analysis, and to exclude data from fires that are.
        - We have updated the demonstrations to include the Q/d analysis for fires identified within the 24-hour back trajectories from the event day, and extended analyses of daily fire growth, emissions quantity, and potential for transport for all fires used in each demonstration. These analyses further support the conceptual model and the tier 3 clear causal analysis provided in each demonstration. Specifically, these analyses provide supporting evidence that (1) the identified fires were actively growing at times likely to impact air quality on the day of identified exceptional event: (2) substantial quantities of ozone precursors were emitted from these growing fires; and, (3) ozone precursors from the fires were transported from the fires to and impacted air quality in Clark County on the event day. With the support of the extended emissions transport analyses, these exceptional event demonstrations meet the clear causal relationship criterion of the Exceptional Events Rule by showing a Tier 3 weight of evidence. [1]

[1] As noted in the ozone exceptional event guidance (U.S. Environmental Protection Agency, 2016), a Tier 3 demonstration must be presented when "the relationship between the wildfire-related emissions and the monitored exceedance or violation cannot clearly be shown using Tier 1 or Tier 2 analyses." Therefore, while the Q/d analyses presented provide evidence that is supportive of a clear causal relationship between the fires identified and the monitored exceedance, these analyses alone are not expected to be sufficient to demonstrate such a relationship in the absence of the Tier 3 analyses.

        - The exceptional event guidance (U.S. Environmental Protection Agency, 2016) describes in detail the method to be used to relate the quantity of smoke emissions and distance of the fire to an exceeding monitor. The resulting quantity, called Q/d, may be used to screen wildfire smoke that meet a conservative threshold of air quality impacts.[2] The approach specifically is described for use in short-range smoke events, because only 24-hour back trajectories are recommended for use in identification of candidate fires. However, the Q/d calculation procedure described by EPA alone is "not sufficient to delineate conditions where sizable O_3 impacts are likely to occur" in tier 3 demonstrations. Plume aging during long-range transport more than 24 hours prior to the event day likely results in a lower Q/d, and may differ significantly from the events used by EPA to establish the minimum Q/d criterion of 100 ton/km.[3] For these reasons, the extended analyses conducted in each demonstration are presented along with and distinguished from the traditional Q/d analyses. The extended analyses nevertheless comport with and further support the overall weight of evidence showing provided by each demonstration.
    - Should consider whether using same-day emission estimates is appropriate, based on HYSPLIT trajectory timing. If the trajectory passes over a fire 24hrs prior to the peak ozone concentration on that day, emissions from the previous day are likely more relevant. This was particularly noticeable for demos that showed transport from fires 2-3 days prior, but Q/D was not provided for the relevant days.
        - Extended emissions estimates and transport analyses have been provided as relevant in each demonstration. The extended analyses (located in each demonstration's Appendix) were conducted to reflect the emissions from each fire on days when evidence supports transport of the smoke emissions to Clark County at a time likely to impact air quality on the day of the identified exceedance. These results support the tier 3 weight of evidence showing provided in each demonstration.
- Ambient monitoring data:
    - **Generally, there is not enough focus on the monitoring data or how it fits the conceptual model of how the smoke caused the exceedances.** The data is presented and simply interpreted as "high" vs "low" and without much consideration of the meaning of individual components or interpretation of increases. There is limited or no discussion about timing. The mechanism of how smoke impacted ozone and how the data reflects that is not clearly laid out. It is too general. When did the smoke impact the area? How did that smoke cause ozone to be elevated? Is there transport of ozone into the area as part of a smoke plume? Is there increased production of ozone due to residual precursors from smoke that came in previously? How is the data consistent with the particular story of how the smoke impacted the sites (based on the other CCR evidence that was provided)? The impacts on ozone from these events are generally not obvious, so this level of detail is badly needed.

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[2] Specifically, fires with a Q/d value meeting the 100 tons/km threshold may qualify for a tier 2 demonstration of a clear causal relationship. However, this threshold is insufficient to identify all cases where ozone impacts from smoke may have occurred. Pages 16-17 of the guidance state "To determine an appropriate and conservative value for the Q/D threshold (below which the EPA recommends Tier 3 analyses for the clear causal relationship), the EPA conducted a review… The reviews and analyses did not conclude that particular O_3 impacts will always occur above a particular value for Q/D. For this reason, a Q/D screening step alone is not sufficient to delineate conditions where sizable O_3 impacts are likely to occur." (U.S. Environmental Protection Agency, 2016).

[3] Jaffe D.A. and Wigder N.L. (2012) Ozone production from wildfires: A critical review. Atmospheric Environment, 51, 1-10, doi: https://doi.org/10.1016/j.atmosenv.2011.11.063

- To include discussion about the timing of wildfire smoke entering the Las Vegas area and the subsequent effects of that smoke, text has been added and existing text has been updated in Section 3.2.4. The causes of enhanced ozone at the exceedance site(s) are discussed in detail, including details on the contribution from wildfire smoke and whether transport of ozone, transport of ozone precursors and subsequent formation of ozone, or both, likely caused the ozone exceedance. Any added or updated text is accompanied by updated figures and additional analysis to provide evidence and context (e.g., elemental carbon, organic carbon analysis). This analysis can be found in Section 3.2.4 of the June 22, June 26, and September 2 wildfire demonstrations.

- The daily plots with historical information do not review days before or after the fire. They should at least include the prior day (or separate plots should include that data). In some cases there may have been a smoke impact that began the previous evening, but it is not clearly shown when looking only at the current day's data. Again, the analysis should factor in the conceptual model for the particular event and include time periods that are relevant to that conceptual model.
    - Figures and text in Section 3.2.4 were added to show pollutant concentrations (ozone, $PM_{2.5}$, CO, NO_2, and TNMOC) a week before and after the exceedance date at each site in Clark County. For existing figures (e.g., diurnal profiles of ozone and NO_2), pollutant data on the day before and day after the exceedance were added. Text was updated corresponding to changes in the figures. This analysis can be found in the June 22, June 26, and September 2 wildfire demonstrations.
- **Comparing day-of-event concentrations at monitoring sites to the statistical information from another site (e.g. comparing to the mean/median, 5th/9th percentiles etc.) is not advised, even if the other site is the only location to have 5 years of data.** Since the different monitoring sites measure different concentration values and patterns, this can make a normal variation appear abnormal (or could mask an abnormal variation for a particular site). It appears that most of the hourly data plots include these kinds of statistical information from Jerome Mack and compare that to the data from the exceeding sites. Instead, we recommend using site-specific data for these plots and noting the uncertainties associated with using percentiles and statistical information based on fewer years of data. (Random bias may be higher, but absolute bias should be lower using this approach.) Even a single year of data could be adequate to show statistical information about normal patterns at a site.
    - The figures and text in Section 3.2.4 in each wildfire document were updated to eliminate inter-site comparisons. Site-specific pollutant data were used to show hourly pollutant trends on the day of the exceedance and the days surrounding the exceedance – no pollutant data from a nearby site was imposed onto a figure that showed site-specific diurnal pollutant profile (i.e., there is no inter-site comparison of diurnal pollutant profiles). In instances where data from non-exceedance site(s) were used (e.g., Jerome Mack) to create diurnal pollutant profile figures, the text emphasizes that these data should not be considered a direct proxy for conditions at the exceedance site(s). If a supporting pollutant (e.g., $PM_{2.5}$) at the exceedance site(s) did not have five years of data, the data were used anyway to show a typical profile. If the exceedance site(s) did not have any supporting pollutant data, the supporting pollutant diurnal profile was not included in the figure. This analysis can be found in Section 3.2.4 in the June 22, June 26, and September 2 wildfire demonstrations.

- Are PM2.5 days potentially associated with wildfire included in the statistical calculations of normal concentrations? If so, this mutes the signal from a potential PM2.5 impact since the wildfire-impacted data is included in determining the 95th percentile values. Ideally these values could be removed in some transparent way (e.g., following a consistent flagging process and then excluding flagged data) to give a better sense of normal, non-fire PM2.5 concentrations, if they are not already. (If they were removed, please include an explanation in the text.)
    - All statistical calculations of $PM_{2.5}$ averages and percentiles exclude days potentially associated with wildfire smoke.
- Suggest adding PM10 plots as well. Looking at when PM2.5 and PM10 increases are correlated or not can be a helpful signature of dust vs other PM sources in Las Vegas. If PM2.5 is increasing while PM10 is increasing more, those are likely dust events.
    - Figures and text were added that show and describe an hourly time series of the ratio of PM_{10} to $PM_{2.5}$ concentrations on the days surrounding the exceedance and on the day of the exceedance to quantify the contribution of dust to $PM_{2.5}$. We also recognize and include in our interpretation that dust and smoke emission events can occur simultaneously in the same region, leading to a mixture of smoke and dust plumes observed downwind. This analysis was performed at each exceedance site where the data was available. This analysis is shown in Section 3.2.4 of the June 26 and September 2 demonstrations.
- **Levoglucosan analysis is not properly contextualized.** Concentrations related to each event are compared to a single non-event day that did not measure any levoglucosan. This day may have been cherry-picked to show the least amount of levoglucosan to compare the analysis day to. There is no information presented to evaluate what normal variation of levoglucosan is on non-smoke impacted days, and therefore it is impossible to discern whether this "positive" levoglucosan indicator is actually outside of the range of normal, non-event concentrations. Additional analysis of non-event levoglucosan data should be included to better contextualize this measurement. Also, is this data available for others to analyze? It does not appear to be in AQS.
    - Nineteen filter samples from Jerome Mack and the collocated Jerome Mack sampler were selected to quantify the background levoglucosan concentrations, and were compared with levoglucosan concentrations on or near each exceptional event day. The background days selected did not have an ozone exceedance and fire/smoke influence was minimal to nonexistent; from a total of 27 samples, 5 days were removed because they were potential EE days in 2018, and 3 days had identifiable smoke influence). The updated levoglucosan analyses can be found in Section 3.2.4 in the June 22, June 26, and September 2 wildfire demonstrations. Levoglucosan filters are not analyzed on a regular basis; therefore, data is not uploaded to AQS.
- Analysis of other speciation data (specifically organic carbon and elemental carbon, possibly others) could be useful - why is this not included?
    - Elemental carbon (EC) and organic carbon (OC) analyses were included in the June 22 demonstration in Section 3.2.4 (Figure 3-28), which is the only event day with concurrent PM-2.5 speciation data

- GAM:
    - **As noted by reviewers on the SOI events, the GAM residuals are consistently biased high at higher measured O3 concentrations.** The plot of residuals by concentration clearly shows this. It undermines the value of the GAM generally. Can anything be done to correct this situation? With high bias in the residuals it will be easier to meet the guidance criteria

showing wildfire impacts, but the confidence interval assumes the residuals are normally distributed, which is not supported by the data. Note, the box charts with residual bin plots don't clearly show this high bias, but this is due to how the bias is evaluated--for example, as a function of GAM predicted value instead of measured value--and how the ranges for the boxes are selected.

- We have re-worked the GAM model to fix the residual bias at high concentrations (i.e., subset to only at ozone season, added and removed parameters [e.g., added previous day's MDA8 ozone, removed minimum temperature because it was already a function of temperature range], changed the fitting of cyclic parameters, added yearly factors for DOY and HYSPLIT back trajectory distance, etc.). We also provide residual histograms and scatter plots to prove that there is not a systematic bias at high concentrations.

- GAM case study table: the case study analysis of higher values is helpful, but concentrations for these data points are still rather low. For example, no exceedances of the 2015 NAAQS are included. Are Clark and STI claiming that none of the exceedances measured at these Clark County sites over the last 5 years were normal, non-event exceedances? This makes it hard to evaluate the performance of the model for the data we are interested in, and seems unlikely given how many exceedances have been measured at these sites.
    - We have pulled together new case studies and now provide both the range and median of MDA8 ozone and residuals for each. We put an emphasis on providing at least one case study per year and that most (if not all) sites in Clark County showed MDA8 ozone ≥ 65 ppb in each case. Six out of the 10 case studies had NAAQS exceedances.
- GAM residual bin plot: I would be interested in seeing a similar plot showing the GAM residuals binned by the observed ozone rather than the fit ozone, i.e., were residuals consistently high at the highest concentrations of observed ozone? This would better address the question of model performance on observed high ozone days.
    - While this would be an interesting graphic, it is not a typical way of evaluating a GAM model. The GAM model will always perform best in the middle of the MDA8 distribution, with over-predictions at low MDA8 and under-predictions at high MDA8 concentrations. A well-fit GAM model should never over predict at the highest end and vice versa. Based on previous literature[4] and concurred exceptional event demonstrations,[5] residual values should be independent of the associated GAM prediction (fit) value. This is why we, and all the other reports cited previously, provide GAM fit vs. residual plots to evaluate bias in the GAM predicted value. Based on our results, we do not find any clear pattern or bias. We also provide histograms of the GAM residual values and show that residuals at all sites are normally distributed with means and medians near zero and low skewness.
    - To further investigate GAM residuals on high observed ozone days, we provide the average non-EE day GAM residual (including a confidence interval) on days when MDA8 ozone is greater than 60 ppb. This statistic likely includes wildfire-influenced days because the last 4 of 7 years were large wildfires years in areas upwind of Clark County. This statistic can help ground the reader by providing an estimate of residuals on high MDA8 ozone days.

[4] Camalier et al., 2007, Jaffe et al., 2013, McClure and Jaffe, 2018, Pernak et al., 2019

[5] Alvadrado et al., 2015, ADEQ, 2016, LDEQ, 2017, and (submitted) TCEQ, 2021

- 2020 emissions profiles were very different due to COVID. Can the GAM capture any of this? How is the model performance for 2020 as compared to other years? We have seen from other agencies/areas that COVID-associated decreases in NOx actually resulted in higher O3 than typical. If this was happening in Las Vegas, it would appear as a higher than usual residual in the model and make it appear that events were contributing to O3 elevation (as opposed to local emission changes). Is there any way to address this added factor of uncertainty?
    - Based on comparisons of MDA8 ozone in Las Vegas in 2020 vs. previous years, we see that there was not a statistical difference in concentrations due to COVID. We do see slightly lower NO_x concentrations (and traffic data in April-May 2020 confirm this decrease), but the ozone concentrations are not significantly different (see Section 2.5 in the SOI demonstrations or the Appendix in the wildfire demonstrations for full details). In addition to this, we examined the April-May GAM residuals in 2020 vs. previous years and do not find a statistical difference in GAM residuals when COVID restrictions were at their maximum. Section 3.3.3 in the June 22, June 26, and September 2 demonstrations provide further details.

- Misc other analysis comments:
    - **It appears that all demos include the full suite of analyses produced, however in some cases, some of the analyses do not support a smoke impact. When this occurs, the reasons for this should be explained in the context of the conceptual model.** For example, if satellite data does not show an impact, explain why (e.g. timing of the image, concentrations low enough that they were not visible from space but still high enough to impact air quality, etc.). Note that if one analysis provides strong evidence to demonstrate a particular element of the CCR relationship (or other rule criteria) it may not be necessary to include other analyses that are less supportive.
        - When an analysis does not fit in with the conceptual model or other main points of analysis, the text was updated to offer an explanation. If a section of analysis was not useful in describing the event, or offered inconclusive evidence, it was moved to the appendix to avoid adding contradictory or confusing evidence within the demonstration, but to avoid the appearance of cherry-picking results.
    - Visibility comparison is done to a clear date on a non-fire day outside of the normal peak ozone season; instead please use a "clear" day from within the general ozone season timeframe (May-September).
        - Visibility images were updated in each wildfire demonstration to show a clear day that occurred during general ozone season. (see Section 3.1.4 in the June 22, June 26, and September 2 wildfire demonstrations)
    - MAIAC aerosol plots - the national plots are not very useful since it is hard to see what is happening over Clark County and the surrounding area as they are so zoomed out. The zoomed in plots don't see to consistently include pre-event plots, making it hard to interpret the data over Clark County. Would be better to include fewer nationally-sized maps and multiple zoomed in maps over the area in question from days before and after the fire. Similar comment for other satellite data analyses.
        - Zoomed-in plots of MAIAC and other satellite products (e.g., CO, NO_2) were added and Las Vegas was labeled. Satellite maps for the day after each event were also added. This was done in Section 3.2.3 in the June 22, June 26, and September 2 wildfire demonstrations.

- **The demos do not really assess local meteorological conditions (temperature, wind speeds, relative humidity, etc.) during the events and whether they are favorable to O3 production or not.** If meteorology on the EE dates are not conducive to O3 formation normally, this would be supportive information to include in the demonstration. For dates where meteorology is generally conducive to O3 formation, the burden of proof for a wildfire O3 EE will necessarily be somewhat higher. The demonstrations should include local meteorological conditions at the time of the exceedances and how they compare to normal conditions at the relevant time of year, and how this information is supportive (or not supportive) of an event impact.
    - The meteorological similar day analysis addresses site-specific meteorological conditions on the date of the exceedances and whether local meteorology is likely the sole cause of high ozone. The meteorological similar day analysis was performed based on EPA Wildfire Guidance and using similar methodology as previously concurred demonstrations. This analysis was performed in Section 3.3.2 in the June 22, June 26, and September 2 wildfire demonstrations.

More minor, potentially generally applicable comments on 2020 events:

- Figure 2-2 caption says the inset shows sites that measure ozone - it appears the inset includes all monitors (including near-road and others that do not include ozone). Caption should be changed to reflect this.
    - The caption was changed. Figure 2-2 now explains that the inset shows "all air quality monitoring sites in the Clark County area.".
- Table 2-1 does not list any pollutants measured for Casino Center and Rancho & Teddy. This is not entirely accurate. Suggest adding a footnote that those sites are source-oriented near road sites and the data is not used to assess event impacts or something along those lines.
    - The caption was changed. Table 2-1 now explains that the "Casino Center and RT are near-road sites and are not used for the EE analysis.".
- Please add information about normal (non-event) emissions of NOx and VOCs in Las Vegas (e.g. in tons per day for relevant months/seasons) to the section about non-event O3 formation. (I believe this may already be available in the 2018 event demos and could easily be copied into the 2020 demos.)
    - Information regarding normal NO_x and VOC emissions in Las Vegas was added to the first paragraph of Section 2.3.
- For maps/plots that do not include it, please clearly identify where the Las Vegas area is located (e.g. with circles/other markers).
    - Maps where important locations are present (i.e., Las Vegas, wildfires) were altered to include indicators of those locations.
- For news articles/media posts, should include screenshots/PDFs as an appendix rather than a link, which requires an additional step for the reader to reference (and links can move, causing the reference to be lost).
    - Screenshots of media coverage referenced in the text was added to the Appendix.
- Natural Event and Not Reasonably Controllable or Preventable sections should reflect the language in the Wildfire O3 guidance regarding wildfires and these two criteria. If the wildfires meet the criteria of being wildfires on wildland (both as defined in 40 CFR 50.1) then they meet these criteria. There is too much focus on the cause of fire ignition, which is largely immaterial if the definitions are met.

- The text in Chapter 4 was updated for the June 22, June 26, and September 2 wildfire demonstrations to reflect the language in 40 CFR 50.1(n), and to describe how these wildfires meet the criteria.

Event specific feedback - 06/22/2020:

- Overall: this appears to be a very challenging event. Magnitude of smoke generation and transport to the Las Vegas area timed with the high ozone is not consistent with the fire causing the exceedances. There doesn't appear to be supporting evidence for smoke impacts in the valley in ambient data. It seems like there isn't a clear path on this one, though perhaps trying to make a stronger argument for the other suggested fires in AZ could be useful.
    - Arizona wildfires were included in the demonstration as the likely cause of smoke impacts in Las Vegas on June 22. Figures and text were updated to present the Arizona wildfires. Analysis on the Arizona wildfires provides the best evidence to support the claim that smoke from wildfires lead to an ozone exceedance in Clark County.
- Wildfire timing compared to high O3. The evidence we have looked at for this fire indicates it did not ignite until the afternoon on June 22 (additional evidence on the fire as seen in reports, timing of news releases, timing of appearance of fire detections via MODIS, documentation with fire information stating start time as 3:35pm on 6/22). This is inconsistent with the timing of highest O3 concentrations on the exceedance day (between 10am-1pm) and even further inconsistent with the time required to transport emissions from the fire to Las Vegas. This is a critical issue; the claim that this fire caused these O3 exceedances does not appear to be technically supportable on this basis alone (independent of other information provided).
    - The first responder to the wildfire in the Mojave National Preserve estimated the ignition time to be between noon and 1 p.m. local standard time. Further analysis showed that the wildfire in the Mojave National Preserve likely did not cause the exceedance on June 22, but rather impacted air quality later in the day. The report was reworked to show that the analysis on the Arizona wildfires provides the best evidence of smoke impacts in Las Vegas on June 22.
- Overall emissions from the fire do not appear large enough to shift O3 concentrations at the magnitude being suggested. The 2018 demos list daily emissions for Clark County as 150 tpd of NOx and 263 tpd of VOCs. (As noted in general comments, this should be added to the 2020 demos.) The total emissions here are a very small fraction of that and that assumes all the emissions traveled to Las Vegas and impacted the monitors there. I am highly skeptical that emissions this low could cause the kinds of exceedances that were observed in Las Vegas (several ppb above the NAAQS).
    - The demonstrations now reflect the smoke emissions from fires in Arizona (Bighorn, Bush, and Mangum Fires) on the observed June 22 exceedance. We find that total emissions of NO_x and VOCs from the Arizona fires combined with emissions from the Ivanpah fire in California were substantially larger than emissions from the Ivanpah fire alone. The weight of evidence of provided in the demonstration indicates a clear causal relationship between the wildfires identified and the observed exceedance.
- Some textual references within the document attributing the fires in AZ as potentially contributing, however, no CCR technical evidence was provided to support this assertion (no trajectories pointing to the fires, no Q/D analysis for the fires, etc). If claiming that AZ fires contributed, need to show transport from those fires and additional fire-specific information to meet CCR requirements. The fires should be fully incorporated into the conceptual model or not referenced at all.

    - The demonstration was reworked to indicate that the Arizona wildfires were the most likely cause of the ozone exceedance, and that the wildfire in the Mojave National Preserve may have affected air quality later in the day on June 22. The analysis, including figures and text, was altered to reflect this change.
- AQI maps - sentence states that high O3 across multiple states corresponded with the presence of wildfire smoke, however, there was no direct comparison between the O3 AQI maps and maps of smoke or smoke tracers. To me this just looks like a normal high ozone day across much of southern CA. Showing PM2.5 AQI would likely be more correlated with potential smoke impacts (as opposed to O3 AQI).
    - $PM_{2.5}$ AQI maps were added to the demonstration. See Figure 3-5 in Section 3.1.2.
- HMS section describes a level of fire activity that doesn't seem to correlate with the maps shown. Includes a statement that there was fire activity "throughout California and Arizona" but activity seems to be limited to a few larger fires in AZ, two small/isolated fires in CA and some fires (possibly ag burning) in Mexico (Mexicali area). Also notes "substantial smoke plumes…covering the southwest United States" but the map again only shows large contiguous smoke plumes over AZ - smoke plumes over CA/NV are very small and limited.
    - The language regarding the HMS smoke and fire figures was adjusted to better reflect the spatial extent of the smoke plumes. See Figure 3-6 in Section 3.1.2.
- HYSPLIT back trajectories initiated at 2pm, but max O3 was measured at 12pm at Joe Neal and 11am or 12pm at Walter Johnson (1pm at Paul Neal) per later plots. Looks like O3 was already decreasing by 2pm. Trajectories should correspond with the highest O3 concentrations or other notable features (e.g. significant increases or changes to slope, deviations from typical diurnal pattern, etc.).
    - The HYSPLIT trajectories were recreated based on the median peak-ozone hour across all affected sites. Additional trajectories were run to show overnight transport from the Arizona wildfires. See Section 3.1.3.
- Trajectories appear to show air parcels passing over the Mojave National Preserve about 12hrs before reaching Las Vegas. This implies the fire would have had to start overnight in order to impact O3 in Las Vegas. Data doesn't support that timing, as mentioned above.
    - The demonstration links the Arizona wildfires, rather than the wildfire in the Mojave National Preserve, to overnight transport and the ozone exceedances. The text and figures were reworked throughout the demonstration to reflect this.
- Media Coverage section is inconsistent with the narrative that the Ivanpah Fire was the main source of smoke causing the exceedances. The section focuses on the larger fires in AZ (for which transport was not shown) and then mentions the Ivanpah fire almost as an afterthought. The text implies the cited Facebook post was on June 22, but appears to be dated June 26. Section asserts "widespread smoky conditions" across the southwest which does not appear to be supported by the data presented (as mentioned above).
    - The Media Coverage Section (3.1.4) was updated to include the Arizona wildfires as the main focus.
- Little-to-no information provided on Grade Fire until the Q/D analysis section. This fire appears to have started on June 22; factoring transport time and looking at HYSPLIT trajectories from the screening, it also appears impossible that this fire could have caused the high O3 concentrations in Las Vegas that resulted in O3 exceedances.
    - The Grade Fire has been removed from the Q/d analysis section and all other portions of the demonstration.

- Q/D table, Daily Growth for Ivanpah fire says "-50" which appears to be a typo since the fire started that day (and a positive emissions number was calculated, so presumably this should be ~1,000).
    - This typo has been corrected. Daily Growth for the Ivanpah fire was 1,000 acres.
- Satellite observations of smoke-emitted pollutants (AOD, CO, NO2) do not seem to support that any smoke was present in the area. Concentrations appear within normal concentration ranges as compared to days before and after.
    - Text was updated to better reflect the satellite observations. Figures that were not useful were moved to the Appendix.
- The demo also notes that there are no observed increases of smoke-related copollutants, such as PM2.5, CO, NO2/NO, or TNMOC. The demo is failing to provide evidence to meet the items in Tier 2, namely showing that smoke impacted the monitors. Most monitoring data and satellite data show no impact.
    - Because the figures that show the diurnal profiles of pollutants (e.g., $PM_{2.5}$, NO_2, CO, etc.) were expanded to include the days surrounding the exceedance day, the smoke influence from the Arizona wildfires was able to be captured and quantified more clearly to support the conceptual model and overall narrative. The new figures show smoke impacts and simultaneous increase in co-pollutants in the hours leading up to the June 22 event.
- Statistical information is compared from different sites (e.g. the hourly CO data from Joe Neal is shown as compared to the statistical metrics from Jerome Mack) and stated that because concentrations are higher than the statistical norm, that supports an event. This ignores the potential for absolute bias in this comparison since the comparison data are coming from a completely different monitoring site that may experience significantly different concentrations under normal conditions. Data should be compared to historical statistical information from the same site, even if there is limited availability of such data.
    - Inter-site comparison was eliminated from the demonstration – all diurnal profiles of pollutants were created using data from one site where data were available. For example, ozone from Joe Neal is plotted with $PM_{2.5}$ from Joe Neal, rather than $PM_{2.5}$ from Jerome Mack.
- Paragraph on 3-41 refers to NOx being "outside of normal seasonal or yearly historical averages" but this doesn't appear to be the case, unless comparing NO2 concentrations from Jerome Mack to statistical information from Joe Neal (which is an issue as previously mentioned).
    - Text was updated to better reflect the new figures, which now show above average spikes in NO_2 (see Figures 3-30 and 3-31)
- See general comment on levoglucosan analysis and not being properly contextualized compared to non-event concentrations. This value is also the lowest levoglucosan concentration presented of all the 2020 event demonstrations.
    - The levoglucosan analysis was updated to include non-wildfire days to represent background values (see Section 3.2.4).
- "Tier 3" section first looks at vertical mixing based on the assertion that the demonstration has shown that smoke is present over the NAA. This would be relevant if there was strong evidence in HMS or satellite data of smoke over the area, but since that evidence is not present, this does not really inform the demo. The HYSPLIT trajectories do not indicate that the smoke was highly lofted either. Normally, smoke plume heights stay within the boundary layer for smaller fires - it takes large, energetic fires to inject plumes above the boundary layer. Downward mixing would be more useful in those kinds of situations but don't really contribute much here.

    - The text in Section 3.3.1 was updated to indicate that vertical mixing is not a central part of the demonstration; rather, the analysis found that transport from the Arizona wildfire smoke likely stayed in the lower troposphere (see Sections 3.1.3, 3.1.4, and 3.3.1)
- GAM unable to show smoke impacts at the 95th quantile, which is the recommended value in the guidance. The GAM is also used as supplementary information to support a demonstration that can show the other criteria, but neither transport from the fire (based on timing) nor impacts at the monitors are demonstrated.
    - While exceeding the 95th quantile impact on the specific EE day is recommended by the guidance, previous conversations with EPA suggested that this metric was not a rule to accept or deny exceptional events. For example, the ADEQ concurred demonstration for June 20, 2015, did not meet this requirement.[6] For this reason, we chose to include a range of 75th to 95th quantile impacts because 4 out of the 7 years in the GAM modeling were high wildfire years. Discussion of the 95th quantile impacts has been added to each GAM section. We have also revised the conceptual model for June 22 to address transport from fires and their surface impacts in Clark County on the event day.
- Natural Event Unlikely to Recur - it's unclear from this section if the Bush Fire is considered a natural event or human activity unlikely to recur (the title also mixes up these two categories). If the Bush Fire meets the definition of a wildfire in 50.1(n) then it is considered a wildfire regardless of whether the fire was ignited by human activity.
    - The text has been updated to describe the Arizona wildfires, including the Bush Fire, as wildfires according to 50.1(n) (see Chapter 4)

Event specific feedback - 06/26/2020:

- Overall: Some inadequacies in evidence of transport from fires and very limited support in ambient data for smoke impacts. There are some areas where additional analysis might prove helpful.
- Concerns about fire timing and activity levels with respect to transport timelines. It does not appear the fires in question were very active in the previous day.
    - Because lightning caused at least two out of three of the fires, archived radar images were used estimate the hour range when the fires could have begun. See Section 3.1.2.
- HMS plots do not really show significant smoke plumes for the fires in question aside from the Rock Path fire, and don't show plume transport towards Las Vegas from Rock Path. Not necessarily indicative that smoke wasn't transported to the valley, but certainly does not provide evidence of such.
    - The HMS smoke and fire maps were updated to include an indicator of Las Vegas and an outline of Clark County. The text was updated to include the caveat that although the smoke plumes are not over Clark County on the day of the exceedance, the HYSPLIT section (3.1.3) provides strong evidence of transport to Clark County by the morning of June 26.
- Matrix back trajectories suggest some potential impact from north but also several trajectories circling up from the south and then back down, not nearing the fires in question. Similarly, narrative on frequency figures doesn't match the data. Most of the trajectories come from the south and don't really intersect Utah much, and definitely not near the fire. Then there is the

[6] Arizona Department of Environmental Quality (2016) State of Arizona exceptional event documentation for wildfire-caused ozone exceedances on June 20, 2015 in the Maricopa nonattainment area. Final report, September. Available at https://static.azdeq.gov/pn/1609_ee_report.pdf.

screening analysis which doesn't show any transport from the Rock Path fire, either. Overall, it is hard to interpret the trajectory evidence presented since there are so many analyses and they don't tell a consistent story.

  - The HYSPLIT figures were reworked to provide a consistent narrative that transport from wildfires influenced ground level air quality in the Las Vegas area. The frequency trajectories were recreated with settings that are consistent with the single site backward trajectory and the backward trajectory matrix. The new frequency trajectories are consistent with the other backward trajectories (see Figure 3-8) in that they show that some transport between the wildfire smoke plumes and Clark County occurred. Further, forward trajectories were initiated a few hours after the approximate ignition of the wildfires (see the RADAR images in Section 3.1.2 and Figures 3-9, 3-10, and 3-11 in Section 3.1.3). The forward trajectories consistently show transport to the Las Vegas area by the morning of June 26.

- Figure 3-13 caption has a typo - should be Twin and Miller fires (not Rock Path fire).
  - This was addressed – the forward trajectories were broken up into forward trajectories from each fire (see Figures 3-9 through 3-11).
- Fire information shows Miller fire did not start until 2:45pm on June 26th - too late to affect June 26 exceedances in Las Vegas. I also looked at fire detections for all fires and they are minimal on June 25. The June 26 activity may have been too late to impact concentrations in the Valley.
  - Available evidence suggests that the Miller Fire started on the night of June 25. Because this was a lightning-initiated fire, and there were no storms in Nevada during the day on June 26, we suggest that the radar images from Section 3.1.2 provide the best estimate of when the Miller Fire actually started. For the Miller Fire to be (1) burning by 2:45 p.m. on June 26, and (2) lightning-initiated, the fire would have needed to start the night before; likely between 5-6 p.m. on June 25 based on radar reflectivity. Although the fire detections and smoke look minimal from the Miller fire, the trajectories still pass near this fire and smoke from a grass fire over the desert would be hard to detect from visible imagery. We still chose to include the Miller fire based on its possible impact due to (1) time of initiation, (2) proximity along the back trajectories, and (3) forward trajectory analysis.
- Inciweb source for Twin Fire shows a perimeter map flown approximately 4pm on 6/26 that shows a fire size of approximately 9,508 acres, less than presented in Q/D calculation. Total emissions from this fire are not so small as the Ivanpah fire, but per unit area are not as impressive as other fires in forests - these desert fires have low fuel loadings. Reduces the likelihood of downwind impacts.
  - The extended analysis (Appendix A) was conducted to reflect fire growth for through 4 PM only for the Twin Fire. Using this method, the Q/d calculated for the Twin Fire is 1.7 tons/km.
- Aerosol satellite data doesn't appear to be clearly elevated (as was asserted in the text). Similar for other satellite data.
  - The text was updated to reflect the satellite images (see Section 3.2.3).
- Monitor pollutant concentrations - PM2.5 is higher than median, but within normal variations. At least one peak is associated with elevated PM10 (likely dust). Second peak less clear. It seems possible that some of this second elevation was from smoke, but there is a disconnect in timing with O3. PM2.5 peaks earlier and decreases a lot when O3 peaks. Also unclear whether this peak is consistent with trajectory timing. Finally, why is Paul Meyer apparently the only site that increased further between 12-2pm? Other sites peaked at 11 or 12 and then decreased. It is

suggestive of a local effect since it is the only monitor seeing that pattern. Since this is the only monitor that violated, that combination is particularly concerning.

  - A PM_{10} to $PM_{2.5}$ ratio analysis at the Paul Meyer station was included to roughly estimate the contribution of dust on PM levels (see Figure 3-26). The analysis indicates that a spike (i.e., high PM_{10} relative to $PM_{2.5}$) above average levels is indicative of dust arriving at the monitor at the end of June 25 and on June 26. This is unsurprising given that the trajectories passed over desert. However, we recognize that dust and smoke emission events can occur simultaneously in the same region, leading to a mixture of smoke and dust plumes observed, such as downwind of desert regions with grassland fires. Almost all the monitors in Las Vegas were in the 60-69 ppb range on June 26. It could be that, as the GAM section (3.3.3) indicates, 2-7 ppb of ozone was contributed by fire emission at Paul Meyer in addition to the local effect described. But for this affect of smoke at Paul Meyer, MDA8 ozone concentrations would likely have been ≤ 70 ppb given that the observed MDA8 ozone was only 73 ppb on June 26.

- Levoglucosan is higher than the 6/22 demo, however as noted in other comments, it is hard to say whether this is outside of normal variation in levoglucosan on non-fire days. It is among the lowest values in the submitted 2020 demos.
  - The levoglucosan analysis was updated to include non-WF levoglucosan concentrations to represent background values (see Section 3.2.4).
- Other monitor impacts are minimal or none. Also see general comment about comparing one site to a different site's historical statistical concentrations and potential misinterpretation.
  - The figures and text were updated and show elevated concentrations of CO at Green Valley (Figure 3-21) and elevated $PM_{2.5}$ concentrations at Paul Meyer. The updated analysis also replaced figures that showed inter-site comparisons with comparisons at one site (e.g., ozone from Paul Meyer is plotted with $PM_{2.5}$ from Paul Meyer, rather than $PM_{2.5}$ from Jerome Mack)
- CALIPSO profiles do not identify elevated aerosol as smoke, but as polluted dust. Demo claims this is likely smoke based on HMS, but there is no specific evidence provided to support that assertion. HMS from the 26th only shows smoke over Utah, not over the areas shown in Figure 3-29 as corresponding to the CALIPSO overpass. There is no clear evidence to conclude that CALIPSO has misidentified the source of these aerosols. As noted above, during early morning hours there was some elevated PM2.5 during corresponding elevations in PM10, supporting that CALIPSO may have accurately identified these aerosols as dust. (Note: 2018 demos appeared to contain a reference to an article explaining the possibility of CALIPSO misidentifying smoke as dust, but that article is not referenced here. Ultimately, CALIPSO identifying an elevated layer of aerosol that may be smoke or dust is not very conclusive support for a smoke impact.)
  - In all of the WF demonstrations, text with citations were added to describe the potential erroneous classification of aerosols over the desert. See Section 3.3.1 in each report. The CALIPSO figures were updated to show the more advanced and reliable “Version 4” CALIOP profiles rather than the uncorrected “Version 3” profiles. The “polluted dust” and “dust” aerosol classification is still present in the area of interest, but research has shown that even the updated “Version 4” CALIOP profiles may not reliably indicate dust. However, for June 26, the most relevant CALIPSO overpass was still to far away from the Miller, Twin, or Rock Path fires to be conclusive. Therefore, these images were move to the Appendix.
- 95th percentile quantile is consistent with a high but attaining concentration without the "additional" impact (although note general high bias in residuals at high observed O3; unclear whether this could meet that standard if residuals at those concentrations were normally

distributed). This is generally supportive, but very close and the GAM analysis only indicates there was an "unusual" impact on O3, not specifically fire. Must be interpreted in the context of the rest of the demo. (See also general criticisms of the GAM model performance.)

  - We believe that having addressed the other issues in this demonstration, the GAM residual can be attributed to upwind smoke influence. Without this additional context, a GAM residual can only be an indicator of "unusual" impact, as correctly stated in this comment.

- Overall, there are large gaps in the conceptual model and it is unfocused. Many of the analyses are unsupportive and much of the data is suggestive that this is a normal exceedance caused by local production, or possibly a local impact at the Paul Meyer site. The transport and monitor impact pieces are not clearly shown and additional information is needed to clearly identify the smoke source and show that it was transported and impacted ground level. There is some very small evidence for a potential (minor) smoke impact around mid-day but it is not clearly timed with O3 increases and there are associated concerns given the apparent local impact. Additional, targeted analysis would likely be required to clearly show transport and monitor impact in a timely manner (note general comments as well).
  - We have included a more specific conceptual model and cleaned up the analysis based on the comments above to provide a more focused demonstration.

Event specific feedback - 09/02/2020

- Not going to provide the same depth of feedback as before. Some general impressions summarized below.
- Overall: monitor-level analysis does not generally support smoke impacts and other data shows clearly that there were large fires generally across CA, but transport doesn't seem clear. The attributed fires are very far and no evidence of smoke along the transport pathway that is suggested at other monitoring sites, no clear evidence of smoke overhead on the exceedance day, etc. There are some areas where additional analysis might prove helpful.
- Seems like lots of large fires across the west, but no clear transport story (smoke seems to largely be missing Las Vegas, transported elsewhere). Based on ambient monitoring data, looks like the strongest story would be to highlight possible smoke impacts overnight the previous night and argue the residual smoke caused increased production, but the demo is not really designed around this conceptual model. Would need to look at overnight trajectories and more analysis of previous day/night data.
  - Additional analysis that included figures that show transport from the wildfires in California was added to the demonstration. New HYSPLIT trajectories (see Figures 3-18, 3-19, 3-21, and 3-22) show evidence of transport from southern California in the hours leading up to September 2 and in the early morning on September 2 (see Section 3.1.3). Text was included to discuss the transport. Sections throughout the demonstration were updated to include the California wildfires (e.g., SQF Lightning Complex) and subsequent impacts on air quality in the Las Vegas area on September 2. Smoke may have missed Clark County, but trajectories passing through the smoke plumes traveled to Clark County in the hours leading up to the September 2 exceedance.
- Demo points to fires in OR/WA as this is the only transport that can be shown using HYSPLIT. Trajectories pass over fires roughly 72hrs prior to exceedances - pretty aged. The fires referenced don't seem particularly large - with dilution during transport, seems unlikely to be concentrated enough to cause increased O3 production in Las Vegas; possibly could have transported O3 from prior production, but don't really see this in the data. Note also that PM2.5 is not elevated at

monitors along the trajectory path (something I looked at separately) - not necessarily a dealbreaker, but the HMS combined with HYSPLIT doesn't really provide a convincing story on smoke transport from the fires selected.

  - The Washington wildfire was removed from the demonstration because the timing of the fire was not conclusive for impacts on September 2. The addition of transport from the wildfires in California provides additional support to smoke impacts at the surface late in the night on September 1 and early in the morning on September 2 in Las Vegas. There is evidence that long-distance transport has the potential to produce ozone enhancements downwind in > 3-day aged plumes from the Oregon fires (see Figure 3-12 in Section 3.1.3). The trajectories (at altitude) pass through the smoke plumes from California and Oregon in the days/hours leading up to the September 2 exceedance.

- Satellite data in general seems to show smoke being transported around Las Vegas - to the north or south, but only limited evidence of smoke over the area itself on any of the days leading up to the event, as well as the day of the event.
  - The text was updated to better represent the satellite images. Although the satellite images do not show clearly enhanced concentrations of CO and NO_2 and increased AOD over Clark County, the HYSPLIT analysis shows that trajectories pass through areas of enhanced concentrations of CO and NO_2 and increased AOD.
- Note Q/D calculated for September 1 and 2, but trajectories pass over the indicated OR fires around 8/30 or 8/31. Need relevant timelines to line up.
  - The extended analyses (Appendix B) provide emissions transport analyses for August 30 and 31 for the identified fires. Based on the uncertainty of HYSPLIT trajectories (approximately 25%), our transport analysis suggests that smoke emitted by fires in Oregon as early as August 30 (Figure 3-15) or as late as September 1 (Figure 3-27) may have been transported to Clark County.
- Ambient data doesn't really show any obvious smoke impact. O3 looks like continued build-up (not increased production) in later hours - this could be a result of local stagnation due to meteorology resulting in continued O3 production for longer than usual. Doesn't seem to be a story here with changed behavior or features in the profile that look unusual. No increase in PM2.5 outside of normal ranges and the pattern looks fairly normal, same for CO. Only levoglucosan shows a potential impact, but we need more context to understand this value. I did also see some potentially slightly elevated OC on 9/3 in the Jerome Mack speciation data, but that would need to be analyzed/contextualized as well, and it's not the same day.
  - Because the figures that show the diurnal profiles of pollutants (e.g., $PM_{2.5}$, NO_2, CO, etc.) were expanded to include the days surrounding the exceedance day, the smoke influence from the California wildfires was able to be captured and quantified more clearly. The new figures, which were also altered to only show pollutants for a single site (i.e., no inter-site comparison), show well above average $PM_{2.5}$ at Walter Johnson and Paul Meyer on September 1 and mostly above average $PM_{2.5}$ at those sites on September 2 (see Figures 3-34 and 3-35). Similarly, CO at both sites show above average concentrations on September 1 and September 2 (see Figures 3-38 and 3-39). A PM_{10} to $PM_{2.5}$ ratio analysis was included for the Paul Meyer and Walter Johnson sites, which shows that elevated $PM_{2.5}$ was likely not a dust event (3-36 and 3-37). The diurnal profile of NO at Jerome Mack and NO_2 profile at Joe Neal and Jerome Mack show a possible response to wildfire smoke entering the Las Vegas area (see Figure 3-40). The Levoglucosan analysis was updated to include the background estimation (see Table 3-11). The Levoglucosan analysis shows strong evidence of wildfire smoke influence.

- Would appreciate a zoomed in view of the CALIPSO overpass track - it's very hard to see where this is relative to Clark County. Also would be good to line up the red box with a specific section of the track.
    - A zoomed in view of the CALIPSO overpass was inserted in the demonstrations that included a CALIPSO section. See Figure 3-43 in Section 3.3.1.

Response to EPA Region 9's SOI Review

Our responses are in red beneath each comment. We greatly appreciate Region 9's willingness to review these demonstrations and the thoroughness of their review, which has helped to strengthen each demonstration.

Detailed comments from EPA on certain Clark O3 EE SOI draft demos (submitted to EPA March 2020):

- There is no longer a requirement to demonstrate that the exceedance would not have occurred "but for" the exceptional event. However, clear-causal practically requires one demonstrate that if all other conditions are the same, those similar days without the influence of the event did not have an exceedance, but the day with the influence did exceed, and the cause may be inferred. One of the best ways to get to that point is to examine meteorologically similar days. This approach is outlined is discussed in section 3.4.4 on page 28 of the EER SOI guidance. Note that analysis of meteorologically similar days for SOI are more involved than for wildfires because the stratospheric air itself affects some of the surface met parameters.
  - The meteorological similar day analysis addresses site-specific meteorological conditions on the date of the exceedances and whether local meteorology is likely the sole cause of high ozone. The meteorological similar day analysis was performed based on EPA SOI Guidance[1] and using similar methodology as a previously concurred demonstration[2]. This analysis was performed in Section 3.5.1 in the May 6, 9, and 28 demonstrations.

- The modeling and HYSPLIT trajectories suggest that O3 from the stratosphere in the western U.S. on these days seems to be decoupled from the surface and not really impacting monitors in Las Vegas. On those 3 days the Las Vegas metropolitan area had very high temperatures, clear skies (which was very evident from the satellite visible image plots in the EE demos), and stagnant/light winds. Those conditions all put together with the large amount of anthropogenic emission in Las Vegas seem to fit a local formation event.
  - We improved this part of the SOI demonstrations by including WACCM[3] cross sections that track the enhanced ozone along the back trajectories from the SOI source region to the surface in Clark County. We also include meteorologically similar day analyses that address site-specific meteorological conditions on the day of the exceedance (such as light winds/high temperatures). With these two techniques, we're able to track enhanced ozone from the source region into Clark County and show that surface ozone was unusually high given the meteorological conditions.

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[1] U.S. Environmental Protection Agency (2018) Guidance on the preparation of exceptional events demonstrations for stratospheric ozone intrusions. Report by the U.S. Environmental Protection Agency Office of Air Quality Planning and Standards, Air Quality Policy Division, Air Quality Assessment Division, Research Triangle Park, NC, EPA-457/B-18-001, November. Available at https://www.epa.gov/sites/production/files/2018-11/documents/exceptional_events_soi_guidance_11-8-2018.pdf.

[2] Arizona Department of Environmental Quality (2018) State of Arizona exceptional event documentation for wildfire-caused ozone exceedances on July 7, 2017 in the Maricopa Nonattainment Area. Final report, May. Available at https://static.azdeq.gov/pn/Ozone_2017ExceptionalEvent.pdf.

[3] https://www.acom.ucar.edu/waccm/plot.shtml

Overall impression is that the meteorological conditions were consistent with local O3 formation and all the indirect supporting evidence is not convincing. It is possible that the stratosphere contributed some sliver of ozone to background but their exceedance seems related to local production given the stagnant meteorology and trajectories that never get to the surface in Las Vegas. The vertical profiles of temperature or relative humidity don't appear to be an indicator of substantial free troposphere/surface air exchange. The regression models are not convincing for O3 attribution. The residual in those could be from anything—transport from California, biomass burning (it would be that if this was a wildfire EE demo), or local production.

- We have added additional analyses to track enhanced ozone from an SOI source region into Clark County in the Model Result Section (3.2.2), examined whether enhanced ozone would be present on meteorologically similar days (3.5.1), and re-worked the GAM model—including analysis on the effect of LA in the GAM residuals—in Section 3.5.2. With these results, we show that ozone was unusually high given the meteorological conditions, compared to meteorologically similar days or as predicted with the GAM.

- May 6, 2020, demo
    i. Sect 2.3 (Page 2-6) The AM3 model also has a systematic high bias for this region; it greatly overestimates stratospheric ozone contributions to the surface. It should not be used for quantitative analysis but might be useful for qualitative assessments. Further, the strat ozone tracer may not totally represent "contribution" due to the way it ages.
        - Section 2-3 has been updated to include AM4 model results rather than AM3 model results. AM4 has reduced ozone biases compared to AM3. The text regards AM4 model results as a qualitative comparison to FAST-LVOS model results.
    ii. Sect 3.1 (page 3-1) Is this the 99th percentile just for the year? Is this just showing that this is a tp 4 day?
        - The 99th percentile is calculated based on six years. See the first paragraph of Section 3.1.
    iii. Sect 3.2.2 (page 3-25) These plots are not consistent with the HYSPLIT. The HYSPLIT in Fig 3-30 to 3-32 suggests air parcels arriving in Las Vegas and the Apex station were between 116W and 114W for two days prior to the exceedance. Making the same plot for May 6 116W, May 6 114W, and May 7 115W at https://www.acom.ucar.edu/waccm/plot.shtml shows a very different evolution. The final figure does show tongues of an intrusion aloft at 38N and 45N, but at 36N it seems if anything disconnected from the surface at 115W.
    This is important because this is not a demonstration for 120W.
        - Figures and text throughout Section 3.2.2 were updated to be consistent with the timing and longitude of transport shown by HYSPLIT. For example, longitudinal cross sections of WACCM-modeled ozone now follow the progression and timing of HYSPLIT trajectories.
    iv. Sect 3.2.2 (page 3-29, figure 3-27) The target location and time are 115.18W, 36.15N and May 7 00Z. Why are we looking at 120W?

- This was originally done to compare with the previous figure which showed CO on May 4 at 120° W. However, this is not as useful as following the trajectory and plotting CO over Clark County on May 6. Instead of including this figure, we plot May 6 CO near the surface in Clark County and 2014-2020 average May CO in Clark County, which is more relevant (see Figure 3-36).

v. Sect 3.2.2 (page 3-30, figure 3-28) What is the mean and standard deviation for this site from this model? Is this "relatively low" concentration very typical or rare?
   - Because we don't have that information for the WACCM model, we include an average May CO concentration map for 2014-2020 from MERRA-2 data in Figure 3-36 and provide a comparison with May 6 CO concentrations from Clark County. This shows that CO concentrations are lower than average on May 6 compared with mean May CO concentrations.

vi. Sect 3.3.2 (page 3-46, figure 3-39) Grand Junction is considerably farther North. The WACCM model does show dry air with high ozone here too.
   - This figure was only included as an example of stratospheric influence in a Skew-T diagram from the EPA SOI guidance document. We have clarified this in the text.

vii. Sect 3.4 (page 3-58, figure 3-51) This could be a compelling figure, but it would need temperature too. RH is a function of specific humidity and temperature. If this day was anomalously hot, then the RH would likely be anomalously low. It would not be evidence of dry air being entrained.
   - Temperature and absolute humidity were added in Figure 3-59.

viii. Sect 3.5.1 (page 3-71, figure 3-60) This is very confusing. The site plots of GAM vs observed do not show any large magnitude low residuals above 60 ppb.
   - We have re-worked the GAM model and find more negative residuals on high ozone days. The residuals show no pattern or bias at high or low predicted values and are normally distributed. See Section 3.5.2 for more details and similarities to GAM results in ADEQ[4] and LDEQ[5] concurred events.

ix. Sect 3.5.1 (page 3-75, figure 3-64) This plot shows a very typical sigmoidal shape to the residual. That is high-biases at low concentrations (<25ppb) and low-biases at high concentrations(>65ppb).

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[4] Arizona Department of Environmental Quality (2016) State of Arizona exceptional event documentation for wildfire-caused ozone exceedances on June 20, 2015 in the Maricopa nonattainment area. Final report, September. Available at https://static.azdeq.gov/pn/1609_ee_report.pdf.

[5] Louisiana Department of Environmental Quality (2018) Louisiana exceptional event of September 14, 2017: analysis of atmospheric processes associated with the ozone exceedance and supporting data. Report submitted to the U.S. EPA Region 6, Dallas, TX, March. Available at https://www.epa.gov/sites/production/files/2018-08/documents/ldeq_ee_demonstration_final_w_appendices.pdf.

This shows that high concentrations will systematically have higher residuals than mid-level concentrations. Note that this includes Non-EE days and EE days.

To make mid-concentration and high-concentration residuals comparable, you would need to detrend.

- See the above comment and Section 3.5.2 for more details on our changes. With the new GAM model, we see that average GAM residual on high ozone, non-EE days (above 60 ppb) are still lower than residuals on EE days.

x. Sect 3.5.1 (page 3-79, figure 3-68) Actually, all high concentration days had a high enhancement. Unless all high days are EE days, this conclusion does not follow. How did these days compare to average residual for > 60 ppb days?

- See the above comment and Section 3.5.2 for more details on our changes to the GAM model. With the new GAM model, we see that average GAM residual on high ozone, non-EE days (above 60 ppb) are still lower than the residuals on the EE days.

xi. Sect 3.5.1 (page 3-80, Table 3-15) Based on the previous figures, the residuals should only be compared to other high concentration days

The standard deviation suggests that Non-EE days have a wide variety of residuals. In fact, a simple 95% confidence interval (MEAN +/- 1.96xSTD) for the residual shows an upper bound ranging from 10.1 to 11.5. ppb by site.

So, we expect the residual is structured and a 95% interval would likely underestimate the true variability at the high end. Perhaps a 99% CI, but that would lead to intervals that include the residuals for May 6th.

- See the above comments and Section 3.5.2 for more details on our changes to the GAM model. We now include 95% confidence intervals around the median for all statistics in the GAM section.

- May 9, 2020 demo
  i. Sect 3.2.2 (Figure 3-13, page 3-18) June 1 does not seem like a more typical "high-ozone" day. Unsure what the definition of typical is, but this day at the monitor of interest has a very low max and a very low minimum concentration.

  What makes this day typical of local formation?

  - Agreed, we instead provide mean May ozone for 2014-2020 from MERRA-2 in comparison with the May 7 values in Figures 3-21 and 3-22.

  ii. Sect 3.2.2 (Figure 3-15, page 3-20) This figure seems to show an anomalously low ozone at 500hPa for the "typical day". This is not supportive, it feels misleading.

  - See above comment.

  iii. Sect 3.2.2 (Figure 3-16, page 3-22) Does the hysplit support this suspicion?

- We improved this part of the SOI demonstrations by including WACCM cross sections that track the enhanced ozone along the HYSPLIT back trajectories from the SOI source region into Clark County.

iv. Sect 3.2.2 (Figure 3-17, page 3-23) RAQMS does show an intrusion over California.
- Agreed

v. Sect 3.2.2 (Figure 3-24, page 3-30) Where are the WACCM cross-sections at 115W
- The WACCM cross sections are now included for ozone along the HYSPLIT back trajectory, including 115° W.

vi. Sect 3.2.2 (Figure 3-26, page 3-34) These are HRRR, not NAM.
- Yes, we have corrected this in the figure caption.

All updates and improvements made to the May 6 and 9 reports were also made to the May 28 report.